(12) UK Patent Application (19) GB (11) 2 041 170 A

(21) Application No 7944226
(22) Date of filing
21 Dec 1979
(30) Priority data
(31) 7902729
(32) 25 Jan 1979
(33) United Kingdom (GB)
(43) Application published
3 Sep 1980
(51) INT CL³ F16K 1/00
(52) Domestic classification
F2V E1C1
(56) Documents cited
GB 1272530
GB 1250512
GB 759170
(58) Field of search
F2V
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(54) **Flow control valve**

(57) A flow control valve comprises a valve member 11 slidable in a bore and having a head 23 for co-operation with a seating defined in the bore between a pair of chambers 15, 16. One chamber 15 is in use connected to a source of liquid at high pressure and the other chamber 16 to a drain. The valve member also has balancing surfaces in the chambers 15, 16. The balancing surface in the chamber 16 has a larger area than the opposed area of the valve head and a restricted outlet 19 extends from the chamber 16. Thus in the closed position the valve member is substantially pressure balanced because the pressure in the chamber 16 is low and as the valve member is moved to the open position the pressure in the 16 chamber increases to act on the larger balancing surface to assist the opening of the valve member.

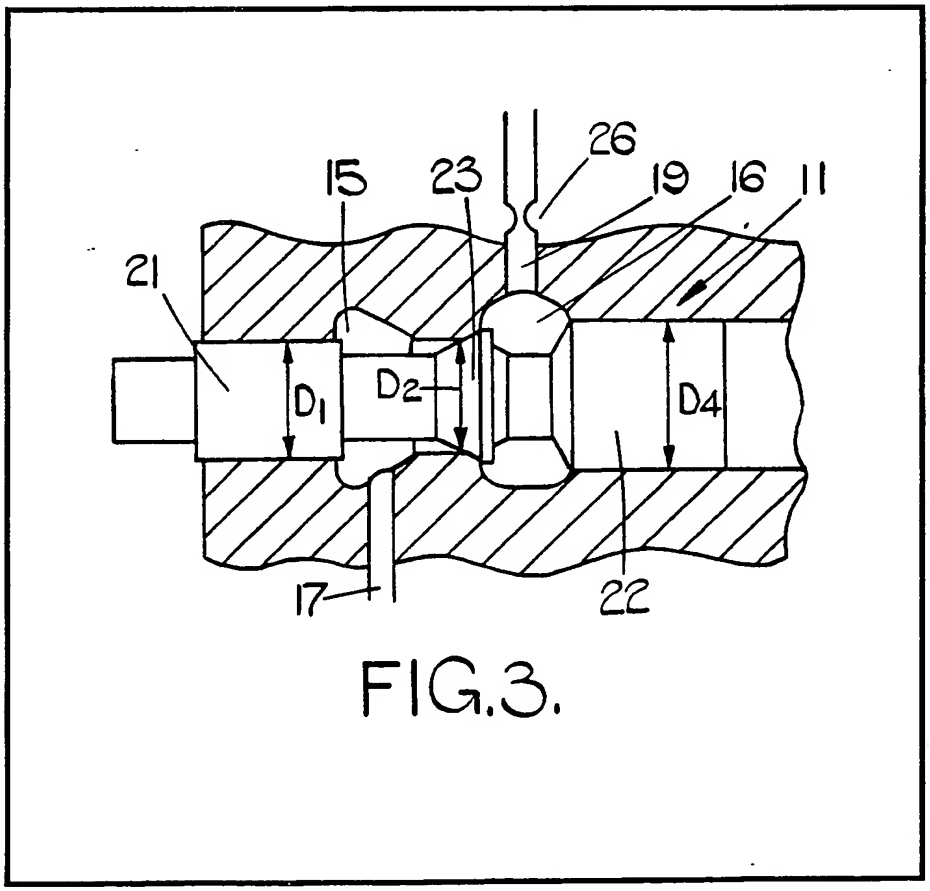

FIG.3.

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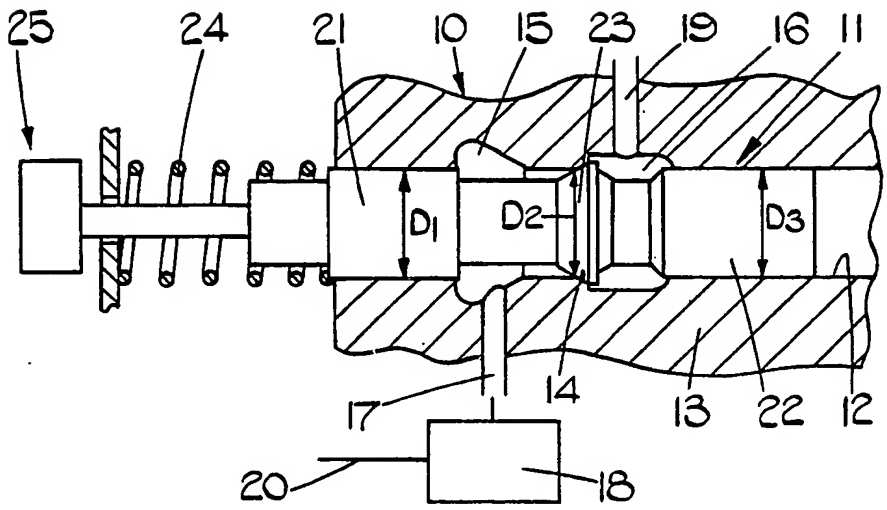

FIG. 1

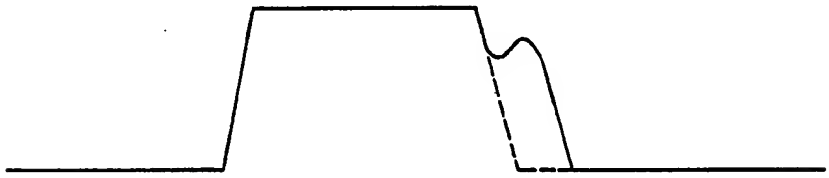

FIG. 2.

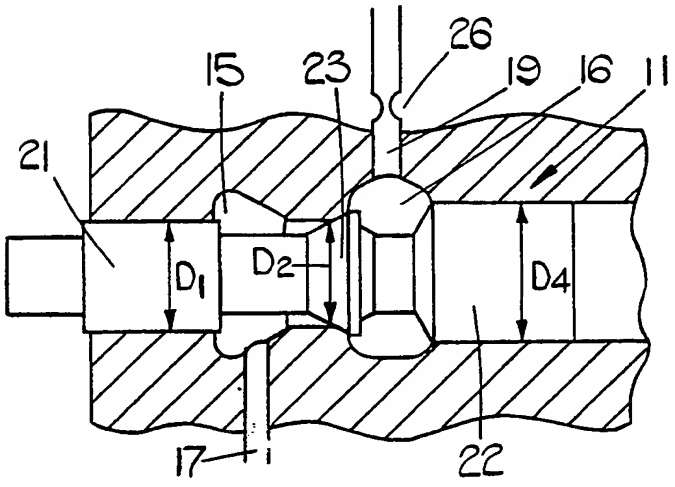

FIG. 3.

SPECIFICATION

Flow control valve

This invention relates to a flow control valve more particularly to a valve for controlling the flow of liquid fuel at high pressure and of the kind comprising an axially movable valve member disposed within a bore, a seating defined intermediate the ends of the bore, a pair of chambers disposed on opposite sides respectively of the seating and a head defined on the valve member for co-operation with the seating, one of said chambers in use being connected to a high pressure source and the other chamber being connected to a drain, the head having a tapered surface for co-operation with the seating, the surface tapering outwardly away from said one chamber.

In order to minimise the forces required to operate the valve it is known to arrange for the valve member to be pressure balanced. This is achieved by providing surfaces on the valve member which are exposed to the pressures in the chambers respectively. The pressure acting on the one surface and exposed to the pressure in the one chamber produces a force acting on the valve member which is opposite to the force produced by the pressure in the one chamber acting against the head. In like fashion the pressure in the other chamber acting on the head is balanced by the pressure in the other chamber acting on the other surface. If the areas of the surfaces are equal to the areas of the valve head then in the closed position of the valve member, the valve member will be pressure balanced and little or no effort will be required to move the valve member to the open position.

Such a valve when moved to an open position, exhibits a disadvantage in that the forces acting on the valve member no longer remain equal and there is a tendency for the resultant force to move the valve member to the closed position. The unbalance of force appears to be due to the pressure drop across the flow path defined between the valve head and the seating. Compensation could be achieved whilst the valve is in the open position, by increasing the area of the valve head or decreasing the area of the one surface exposed to the pressure in the one chamber. This would mean, however, that in the closed position the valve member would not be pressure balanced so that considerable force would need to be applied to the valve member to maintain it in the closed position. The object of the present invention is to provide a flow control valve of the kind specified in a simple and convenient form.

According to the invention a flow control valve of the kind specified comprises a pair of surfaces defined on the valve member on opposite sides of the valve head, said surfaces being subject to the liquid pressures in said chambers respectively to produce forces on the valve member acting in the opposite direction to the forces produced on the valve head by the pressures in said chambers, the one surface exposed to the pressure in said one chamber being substantially equal in area to the area of the valve head exposed to the pressure in said one chamber, the area of the other surface exposed to the pressure in the other chamber being greater than the area of the valve head exposed to the pressure in the other chamber and means for restricting the rate of flow of liquid from said other chamber.

The invention will now be described with reference to the accompanying drawings in which:–

Figure 1 is a sectional side elevation of a known form of valve,

Figure 2 is a graph of valve lift against time for the valve which is shown in Fig. 1, and

Figure 3 shows a valve in accordance with the invention.

Referring to Fig. 1 of the drawing, the control valve is indicated at 10 and it comprises a valve member slidable within a bore 12 formed in a supporting body 13. The bore 12 is of cylindrical form and defines a seating 14 intermediate its ends. Moreover, on opposite sides of the seating the bore defines a pair of chambers 15, 16, the chamber 15 being connected by means of a passage 17 to the pumping chamber of a fuel injection pump 18. The chamber 16 is connected to a drain by way of a passage 19. In addition, the injection pump has an outlet 20 which in use is connected to a fuel injection nozzle of an engine with which the pump is associated and the arrangement is such that during a pumping stroke of the injection pump 18, when the valve 10 is in the closed position as shown in Fig. 1, fuel will be delivered through the outlet 20 to the associated engine. If during delivery of fuel the valve is opened then fuel flow will occur between the passages 17 and 19 and no further fuel will be delivered through the outlet 20.

The valve member 11 is of generally cylindrical form, the two end portions 21, 22 being of the same diameter. Intermediate the end portions there is defined a valve head 23 for co-operation with the seating 14, the head having a tapered face for co-operation with the seating and the taper extending outwardly away from the chamber 15. On opposite sides of the head portion, the valve member is of reduced diameter, the reduced diameter portions coinciding generally with the chambers 15, 16.

The diameter D1 of the end portion 21 is equal to the diameter D3 of the end portion 22 and also to the diameter D2 across the seating 14. With the valve in the closed position, the area of the valve head exposed to pressure in the chamber 15 is substantially equal to the area of the annular surface of the

portion 21 which is exposed to the pressure in the chamber 15. As a result, the forces acting on the valve member due to pressure within the chamber 15 will be substantially equal. In similar fashion the pressure in the chamber 19 acts against the annular end surface of the portion 22 of the valve member and this is substantially equal to the effective area of the valve head. As a result the valve member is pressure balanced and little or no force is required to maintain the valve head in contact with the seating or to lift the valve head from the seating when it is required to open the valve.

As shown in Fig. 1, a coiled compression spring 24 is provided to effect opening of the valve and an electromagnetic device 25 is provided and which when energised, effects closure of the valve.

In Fig. 2 there is shown a graph of valve lift against time. The upper line represents the portion of the valve member when closed and the lower line the position of the valve member when open with the horizontal axis representing time. It will be seen that fairly rapid closure of the valve head 23 onto the seating 14 is obtained but when the electromagnetic device 25 is de-energised, and the spring 24 attempted to open the valve then whilst the initial rate of opening is fairly high for a short period of time there is a tendancy for the valve member to move towards the closed position and this is then followed by movement of the valve member towards the open position. The pressure of fuel supplied by the injection pump in the apparatus for which the valve was designed, is in the order 21.1 Kg/mm^2. When the valve lifts from its seating there is a pressure drop along the flow path defined between the valve head and the seating with a result that whilst the pressure in the chamber 15 is still applied to the annular end surface of the portion 21 of the valve member, the pressure applied to the valve head is reduced. As a result the valve member tends to move towards a position in which the out of balance force on the valve member is balanced by the force exerted by the spring. The valve member therefore acts to restrict the flow of fuel from the injection pump.

As previously explained if the effective diameter of the end portion 21 of the valve member is reduced to counteract the above described effect then in the closed position of the valve member it will not be pressure balanced and a considerable force would have to be exerted by the electromagnetic means to maintain it in the closed position.

The aforesaid disadvantage can be overcome by increasing the diameter of the portion 22 of the valve member and by providing a restriction 26 in the passage 19. In the closed position of the valve therefore, any pressure in the chamber 16 will result in unbalanced forces on the valve member but the pressure in the chamber 16 is very small as compared with the pressure in the chamber 15 and the out of balance force can be neglected. When the valve member is moved to the open position, however, the pressure in the chamber 16 rises and the difference in the forces acting on the valve member due to the differing diameters D2, D4 opposes the tendency for the valve member to move to the closed position. The rise in pressure in the chamber 16 is facilitated by the restriction 26 in the passage 19. Thus, opening of the valve member tends to follow the path shown in dotted outline in Fig. 2. The size of the restrictor 26 has to be chosen so that there is no substantial restriction of the flow of fuel. Whilst a restriction has been shown in the passage 19 it is of course possible to choose the diameter of the passage so that the required degree of restriction is obtained.

CLAIMS

1. A flow control valve for controlling the flow of liquid at high pressure comprising an axially movable valve member disposed in a bore, a seating defined intermediate the ends of the bore a pair of chambers disposed on opposite sides of the seating and a head defined on the valve member for co-operation with the seating, one of said chambers in use being connected to a high pressure source of liquid and the other being connected to a drain, the head having a tapered surface for co-operation with the seating which tapers away from said one chamber characterised by a pair of surfaces defined on the valve member on opposite sides of the valve head, said surfaces being subject to the liquid pressures in said chambers respectively to produce forces on the valve member acting in the opposite direction to the forces produced on the valve head by the pressures in said chambers, the one surface exposed to the pressure in said one chamber being substantially equal in area to the area of the valve head exposed to the pressure in said one chamber, the area of the other surface exposed to the pressure in the other chamber being greater than the area of the valve head exposed to the pressure in the other chamber and means for restricting the rate of flow of liquid from said other chamber.

2. A flow control valve according to claim 1 characterised in that said means for restricting the rate of flow comprises a restriction formed in a passage extending from said other chamber.

3. A flow control valve substantially as hereinbefore described with reference to Fig. 3 of the accompanying drawings.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1980.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.